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Jul 77

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NATIONAL EUTROPHICATION SURVEY

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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REPORT
ON
MAYFIELD LAKE
LEWIS COUNTY
WASHINGTON
EPA REGION X
WORKING PAPER NO. 870

WITH THE COOPERATION OF THE
WASHINGTON DEPARTMENT OF ECOLOGY
AND THE
WASHINGTON NATIONAL GUARD
JULY, 1977

REPORT ON MAYFIELD LAKE

LEWIS COUNTY, WASHINGTON

EPA REGION X

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 870

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

July 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Washington Department of Ecology for professional involvement, to the Washington National Guard for conducting the tributary sampling phase of the Survey, and to those Washington wastewater treatment plant operators who provided effluent samples and flow data.

Ms. Barbara Blau, Lake Restoration Program, and the staff of the Washington Department of Ecology, Lake Restoration Program, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

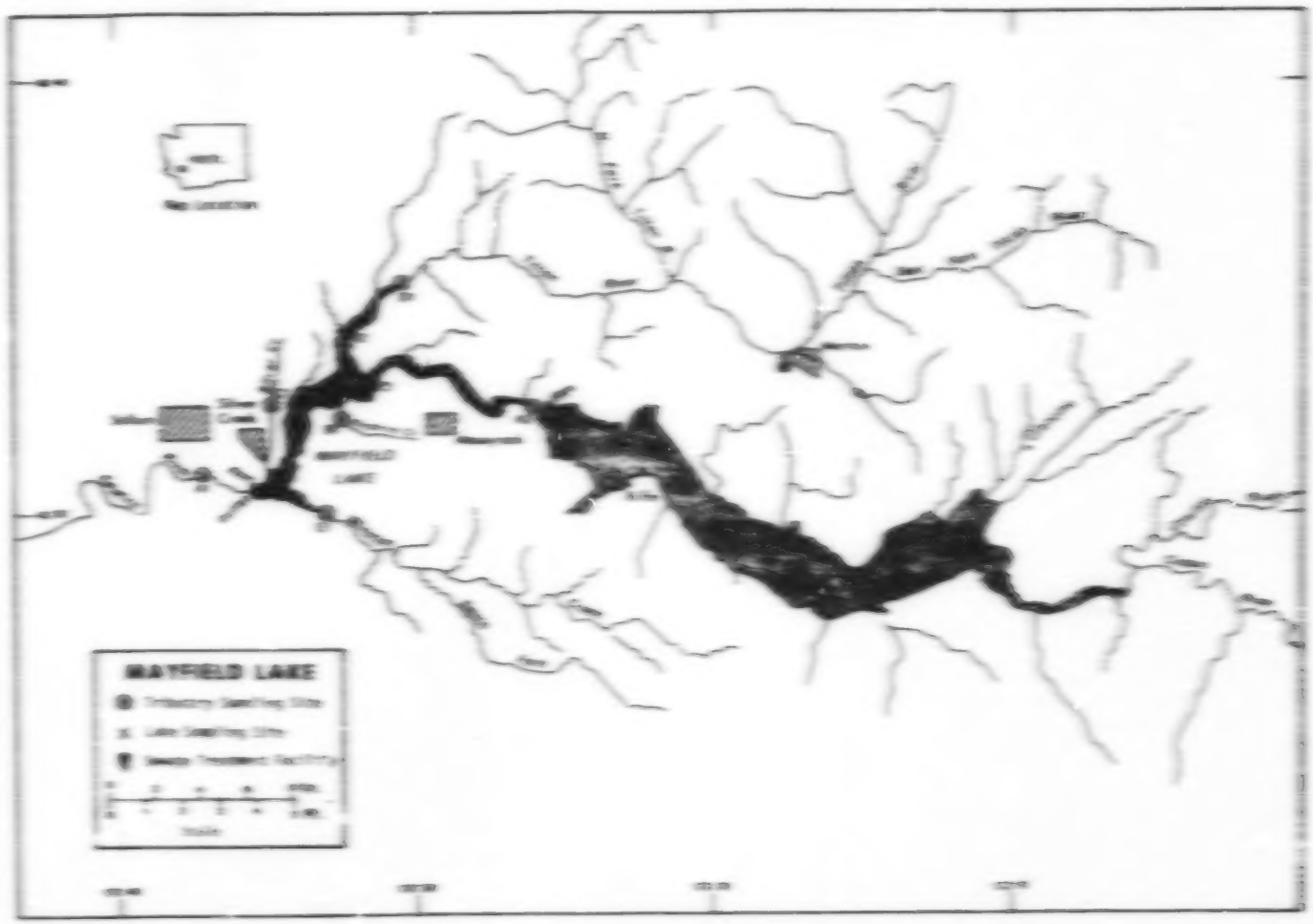
Major General Howard S. McGee, Adjutant General of Washington, and Project Officer Colonel Clinton C. Johnson, who directed the volunteer efforts of the Washington National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WASHINGTON

LAKE NAME	COUNTY
American Lake	Pierce
Banks Lake	Grant, Douglas
Chelan Lake	Chelan
Diamond Lake	Pend Oreille
Green Lake	King
Keechelus Lake	Kittitas
Mayfield Lake	Lewis
Medical Lake	Spokane
Moses Lake	Grant
Ozette Lake	Clallam
Sammamish Lake	King
Lake Whatcom	Whatcom
Lower Granite Reservoir	Garfield, Whatcom


MAYFIELD LAKE

REPORT ON MAYFIELD LAKE, WASHINGTON
STORET NO. 5307

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate Mayfield Lake is mesotrophic. Chlorophyll a values ranged from 0.5 ug/l to 18.0 ug/l, with a mean of 4.2 ug/l. The potential for primary productivity as measured by algal assay control yields was low. Of the 13 Washington Lakes sampled in 1975, 7 had higher median total phosphorus and median inorganic nitrogen values, and 6 had greater median dissolved orthophosphorus levels.

Survey limnologists did not report any problem conditions during their visits to the lake.

*See Appendix E.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Mayfield Lake was limited by available phosphorus levels during the sample collection times (03/20/75, 10/30/75). Lake data suggest nitrogen limitation during the spring and summer sample collection times and phosphorus limitation during fall.

C. Nutrient Controllability:

1. Point sources -

Point sources were estimated to have contributed 0.9% of the total phosphorus load to Mayfield Lake. The city of Morton contributed this entire load. In addition, a fish hatchery discharges to the northeastern end of the lake, but nutrient contributions from this source are not known.

The loading calculations for Mayfield Lake indicate a net export of phosphorus from the lake. This apparent export may be attributable to lack of information on the nutrient input from unknown or unmeasured point sources, to failure to adequately depict annual nutrient loadings from ungaged tributaries with available estimation means, or to sampling error. As is, the calculated phosphorus loading for Mayfield Lake is 11.36 g $P/m^2/yr$; additional sampling is needed to determine the true nutrient budget of Mayfield Lake and the significance of the annual phosphorus loading to the trophic state of the lake.

2. Nonpoint sources -

The mean annual phosphorus load from nonpoint sources accounted for 99.1% of the total load reaching Mayfield Lake. The Cowlitz River contributed 75.5%, Tilton River contributed 16.7%, Klickitat Creek contributed 0.6%, and minor tributaries and immediate drainage were estimated to have contributed 6.1% of the total phosphorus load.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by Walcott (1965). Tributary flow data were provided by the Washington District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 8.90 km^2.
2. Mean depth: 17.6 meters.
3. Maximum depth: 56.4 meters.
4. Volume: 156,653 x 10^6 m^3.
5. Mean hydraulic retention time: 9 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area (km^2)	Mean flow (m^3/sec)
A-2 Cowlitz River	2,988.9	155.66
B-1 Kiickitat Creek	26.9	0.66
B-1 Tilton River	365.2	23.98
Minor tributaries and immediate drainage -	236.1	7.85
Totals	3,617.1	188.35
2. Outlet - A-1 Cowlitz River	3,620.0	194.19

C. Precipitation:

1. Year of sampling: 133.7 cm.
2. Mean annual: 116.2 cm.

III. LAKE WATER QUALITY SUMMARY

Mayfield Lake was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 53.3 meters at Station 01, 30.8 meters at Station 02, and 18.0 meters at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

[illegible] LAKE
STREET CODE [illegible]

[illegible] AND CHEMICAL CHARACTERISTICS

PARAMETER	NP	[illegible]	[illegible]	[illegible]	NP	[illegible]	[illegible]	[illegible]	NP	[illegible]	[illegible]	[illegible]
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PH (STANDARD UNITS)												
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TOTAL ALKALINITY (MG/L)												
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TOTAL P (MG/L)												
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DISSOLVED [illegible] P (MG/L)												
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NITRATE (MG/L)												
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AMMONIA (MG/L)												
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[illegible]	3	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]
CHLORIDE (MG/L)												
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[illegible]	3	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]
SECCHI DISC (METERS)	3	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]

* N = NO. OF SAMPLES
** MINIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED IN THAT ZONE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/26/75	1. Melosira	297
	2. Cryptomonas	61
	3. Chroomonas	27
	4. Pennate Diatom	27
	Other genera	xxx
	Total	432
07/17/75	1. Asterionella	1,223
	2. Tabellaria	100
	3. Cryptomonas	25
	Other genera	xxx
	Total	1,348
10/10/75	1. Asterionella	145
	2. Chroomonas	29
	Other genera	xxx
	Total	174

2. Chlorophyll A -

Sampling Date	Station Number	Chlorophyll A (ug/l)
04/28/75	01	1.8
	02	1.4
	03	1.7
07/17/75	01	18.0
	02	8.8
	03	---
10/30/75	01	8.8
	02	8.8
	03	8.8

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 03/28/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.006	0.088	0.1
0.05 P	0.056	0.088	2.6
0.05 P + 1.0 N	0.056	1.088	25.2
1.00 N	0.006	1.088	0.1

b. 10/30/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.140	0.2
0.05 P	0.055	0.140	7.3
0.05 P + 1.0 N	0.055	1.140	24.4
1.00 N	0.005	1.140	0.2

B. Discussion -

The control yields of the assay algs, Selenastrum capricornutum, indicate that the potential for primary productivity in Mayfield Lake during both sample collection times (03/28/75, 10/30/75) was low. A significant increase in growth over that of the control occurred when phosphorus was added alone and in combination with nitrogen, indicating phosphorus limitation. Spikes of nitrogen alone did not produce an increase in yield beyond that of the control.

Lake data show a mean inorganic nitrogen to orthophosphorus ratio (N/P) of 13/1, 6/1, and 28/1 in the spring, summer and fall, respectively, suggesting nitrogen limitation in the spring and summer, and phosphorus limitation in the fall (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Washington National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of January when two samples were collected. Sampling was begun in September 1974, and was completed in August 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Washington District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/yr$, in Covlitz River at Station A-2 and multiplying the means by the ZZ area in km^2.

The operator of the Morton wastewater treatment plant provided monthly effluent samples and corresponding flow data.

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Morton	1,250	Trickling Filter	1.536	Tilton River

2. Known industrial - None

*Provided by treatment plant operator.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Cowlitz River	76,340	75.5
B-1 Kiickitat Creek	645	0.6
D-1 Tilton River	16,855	16.7
b. Minor tributaries and immediate drainage (nonpoint load) -	6,140	6.1
c. Known municipal STP's -		
Morton	935	0.9
d. Septic tanks* -	10	<0.1
e. Known industrial - None		
f. Direct precipitation** -	195	0.2
Total	101,090	100.0
2. Outputs - A-1 Cowlitz River	102,690	
3. Net annual P export *** -	1,610	

*Estimate based on 30 lakeshore residences.
**Estimated (See NES Working Paper No. 175).
***Export probably due to unknown sources and/or sampling error.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Cowlitz River	1,144,155	71.7
B-1 Kiickitat Creek	33,600	2.1
D-1 Tilton River	312,715	19.6
b. Minor tributaries and immediate drainage (nonpoint load) -	90,425	5.7
c. Known municipal STP's -		
Morton	4,105	0.3
d. Septic tanks* -	320	<0.1
e. Known industrial - None		
f. Direct precipitation** -	9,610	0.6
Total	1,594,930	100.0
2. Outputs - A-1 Cowlitz River	1,548,220	
3. Net annual N accumulation -	46,710	

*Estimate based on 30 lakeshore residences.
**Estimated (See NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Cowlitz River	26	383
Kiickitat Creek	24	1,249
Tilton River	46	856

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
E-1 Silver Creek	0.032	0.892
E-1 Winston Creek	0.036	0.750

F. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Mayfield Lake	11.36
Vollenweider's "eutrophic" loading	5.54
Vollenweider's "oligotrophic" loading	0.77

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Specia' Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

Wolcott, E. E. 1965. Lakes of Washington, Volume I. Washington Division of Water Resources, Water Supply Bulletin, 14 and 15.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

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APPENDIX C
PHYSICAL AND CHEMICAL DATA

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APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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[illegible]	14	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[redacted]

[redacted]

DATE	TIME	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	11	29	[redacted]	0.200	0.205	0.210	0.229
[redacted]	14	49	[redacted]	0.202	0.200	0.209	0.209
[redacted]	14	00	[redacted]	0.204	0.200	0.203	0.200
[redacted]	13	35	[redacted]	0.206	0.200	0.203	0.200
[redacted]	12	47	[redacted]	0.206	0.209	0.203	0.200
[redacted]	10	45	[redacted]	0.202	0.202	0.209	0.210
[redacted]	11	55	[redacted]	0.204	0.209	0.206	0.209
[redacted]	14	35	[redacted]	0.209	0.202	0.205	0.209
[redacted]	12	46	[redacted]	0.204	0.209	0.205	0.210
[redacted]	11	39	[redacted]	0.205	0.207	0.205	0.210
[redacted]	14	29	[redacted]	0.205	0.200	0.205	0.205

[redacted]

[illegible]

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							

[illegible]

[illegible]

[illegible]

[illegible]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF WASHINGTON

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Washington lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in µg/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SUB-MEAN SEC	MEAN CHLORA	75TH PCTL	MEDIAN SECCHI DEPTH
9301	AMERICAN LAKE	29 (31)	50 (61)	67 (81)	58 (69)	4 (5)	58 (73)
9302	BANKS LAKE	42 (51)	107 (123)	58 (73)	25 (31)	46 (51)	72 (91)
9303	CHELAN LAKE	100 (123)	67 (81)	100 (123)	100 (123)	100 (123)	92 (111)
9304	DIAMOND LAKE	67 (73)	75 (91)	75 (93)	27 (29)	33 (41)	25 (31)
9305	GREEN LAKE	29 (33)	83 (101)	17 (25)	75 (93)	67 (73)	46 (53)
9306	HEDDEMAN LAKE	89 (111)	92 (113)	92 (111)	93 (109)	75 (93)	100 (121)
9307	HATFIELD LAKE	67 (73)	54 (73)	33 (41)	58 (73)	42 (73)	71 (85)
9308	MEDICAL LAKE	0 (81)	0 (13)	42 (53)	0 (13)	4 (83)	0 (85)
9309	MOSES LAKE	0 (13)	29 (33)	0 (0)	0 (93)	21 (25)	0 (13)
9310	OSETTE LAKE	75 (93)	42 (53)	25 (33)	92 (111)	87 (103)	33 (41)
9311	SAMMAMISH LAKE	58 (61)	17 (25)	58 (69)	33 (41)	21 (25)	83 (103)
9312	WINTON LAKE	83 (103)	0 (83)	83 (103)	67 (83)	46 (53)	46 (53)
9313	LOWER GRANITE RESERVOIR	17 (25)	29 (33)	0 (13)	42 (53)	67 (103)	17 (25)